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THIRTY YEARS OF PUBLIC SERVICE PERFORMED BY  
THE DOWNY MILDEW WARNING SERVICE FOR  
THE PROTECTION OF VINEYARDS IN  
THE ACQUI DISTRICT OF ITALY

[This is a translation of an article in Italian by Dr. Alberto Messori, Inspector General of the Italian Ministry of Agriculture and Forests and Head of the Turin Province Agricultural Inspection Service. This paper was presented at the Third International Biometeorological Congress at Pau, France, 1-7 September 1963].

The Environment

Acqui-Terme is a pleasant town located in the Monferrato zone of Piedmont in Northern Italy. Its famous spring waters that rise from deep inside the bowels of the earth are used to treat rheumatic ailments and, in contrast with the debilitating effect induced by mud applications used in the treatment of such ailments, Acqui-Terme's invigorating wines are nutritious, energy-giving, savory and sweet-smelling, rich both in body and in color. These wines have characteristics all their own and are renowned from ancient times as a product of Piedmont. The luxuriant vineyards from which they are produced are the outstanding feature of the agriculture of the region, creating a picturesque panorama dominating the gently rolling hills which encircle the town.

This green, hilly area, extending some tens of kilometers in every direction from the town and intensely cultivated with vineyards, with wine growing predominating both in acreage planted and quality of product, has been the scene of a very interesting and effective public service carried out over the past thirty years, namely, the downy mildew warning service, established to carry out an organized campaign against plasmopara viticola.

The climate of the area is continental. Winters are severe, damp and foggy, with temperatures which go below  $-10^{\circ}\text{C}.$ , while temperatures ranging over  $35^{\circ}\text{C}.$  between maximum and minimum are not unusual in the summer months. Rain-fall from fall to spring is generally excessive, while there is a persistent dry period during the summer.

#### Beginnings of the Warning Service

There are 32 separate municipalities in the Acqui-Terme district (Alessandria Province), with a total of 18,000 hectares planted to vineyards, all responding to a single call: When, during the late spring or early summer, conditions are found to be favorable for the downy mildew to start its biological cycle of development, the farmers' own prejudices and preconceptions lose all validity at the sound of the steeple-bell which gives the warning as to the right time to spray the vines with solution for protection against attack by downy mildew. The winegrowers are right, too, in placing their blind faith in this service, because it can truly be said that since it started it has never failed to live up to the expectations of those winegrowers who have always followed it as a guide.

Sometimes it has happened that the alarm was given at a time of heightened market activities with the market-places crowded with winegrowers, selling their products. At the sound of the distinctive alarm warning given by the church-steeple bells, the farmers break off their business and desert the market squares so fast that one might almost have thought that an alarm siren signalling immediate danger had been sounded. The signal, when given, has a sense of urgency and the farmers know that once it is given there is not time to lose.

This extensive district of intensive winegrowing possesses a warning system to give notice of those periods during which action must be taken to protect the grapevines, known for good reason as a "technical university" specializing in anti-mildew investigations.

The warning service, which is original to the winegrowers of the Acqui district, goes back to 1928 when the then head of the Acqui section of the Field Unit of the University Agricultural Extension Service, Dr. Giovanni Picchio, supported and prompted by Prof. Luigi Gabotto of the Plant Pathology Section of the same extension service for the Province of Alessandria, in putting into effect the worthy

initiative, became overcome with the idea of trying out the alarm system as a way of better organizing concerted action in application of sprays to combat downy mildew, thereby making the work more effective, reducing waste of the spray compounds and cutting down the waste effort involved in spraying at the wrong time or ineffectively.

The first in Italy to mention the advantages of setting up a downy-mildew warning service for winegrowers was Senator Arturo Marescalchi. Later, in 1918, the first experiments were carried out by Prof. Luigi Gabotto, expert in plant pathology at the Alessandria Agricultural Extension Service.

Tests and observations were carried out cautiously during the first few years since first of all a study had to be made of the downy mildew's life cycle in the environment peculiar to the Acqui district, taking into account, more specifically, the different microclimates in the various valleys of the Monferrato zone, to find out whether this mildew actually behaved biologically in the manner known up to that time or whether any changes would be needed in plan of action indicated by the limited information then available.

To this end several vineyards owned by winegrowers, who showed complete faith in the progress of modern science, were investigated and their vines were sprayed. As soon as the typical time scale of incubation of the mildew had been worked out for one small, local area, the size of the area covered by the experiment was gradually expanded and subsequently the present-day public service provided by the downy-mildew warning service was set up, a service which Prof. Baldacci traces back to the "Service des avvertissement agricoles" (Crop warning service) founded by the French government.

#### Biological Behavior of the Downy Mildew, Plasmopara Viticola and Steps to Combat Infection

As is known, discovery of the effect which copper has in protecting grapevines against downy mildew did not put an end to scientific research on this plant disease. Instead, laboratory research and field studies were stepped up to penetrate even deeper into the unknown life cycle of this harmful parasite. At the same time that further studies were being made of different copper solutions to intensify their effectiveness in combatting the mildew, thorough

biological research was carried out on plasmopara viticola to further improve the effectiveness of the measures taken against it.

The first mention of the development of plasmopara viticola comes from the German investigator, Müller, who above all brought out the fact that the first infection takes place in spring due to the conidia which come from oöspores which matured on the vine, particularly in the leaves, during the preceding year. Müller also found that a more or less long period of incubation was required for the mildew's reproductive cells to germinate and that the ambient temperature must remain above certain minimum levels, while there must also be sufficient moisture in the air.

It was found, then, that the biological cycle of the mildew obeyed certain laws so that one could time the applications of copper-lime preparations to increase their effectiveness.

The assumptions used as a basis were substantially those formulated by Müller in laboratory tests according to which a time scale was drawn up to represent the general, basic period of incubation, in reference to the downy mildew's life cycle.

The first fifteen days in succession up to the middle of the month of May, a period of 11-14 days for the end of May, 10-13 days for the middle of April [sic. See table of incubation periods. The writer evidently intended to say June instead of April at this point] and 7-10 days for the end of this month, and so on, reducing to 4-7 days towards the end of August when temperatures at no time go below +10°C. are the number of days required for incubation and represent the fundamental data necessary to control of the biological development of the mildew.

An exception to this rule was brought out as a result of the earliest applications and practical observations carried out in the Acoi district by Dr. Clemente showing that temperatures of +10°C. were not to be considered as any absolute minimum for incubation of the mildew since even at lower temperatures it was shown that the period of incubation and contamination could take place if the maximum temperatures during the day exceeded 20° or more.

A number of years of experiments led to setting up a time-table for incubation of the mildew in a given area and this time-table has already been tried and proven over a period of decades (Dr. Clemente, Ricci). This time schedule is based on the fact that the duration of the downy mildew's life cycle is calculated on the basis of the average daily temperature from the time when infection starts through the entire period of its incubation.

The table showing the different periods of incubation is given in the appendix to this paper and the effect of the time at which the infection occurs has on the length of incubation can be seen in the table. This table was based on the criteria outlined above and it will be understood that it is applicable only to the particular area being dealt with.

#### How to Use the Table

Lengths of time of incubation are shown on the horizontal line to the right of the ten-day period in the first column at the left during which the infection started or during which the period of incubation took place. The average temperature recorded during the incubation period is shown at the head of each vertical row. The point at which the corresponding vertical row and horizontal line cross gives the corresponding incubation time.

Fractions of degrees centigrade can be interpolated by comparing adjacent columns. If the period of incubation extends from one ten-day period into another, one must interpolate between the figures in one horizontal line and the adjacent horizontal line corresponding to the two ten-day periods during which incubation takes place.

In order to choose from the maxima and minima given in the individual positions on the table and in order to estimate the oft-occurring prolongation of the incubation periods which take place, one must base evaluations on the humidity of the air (measurements of relative humidity, rainfall, fog, winds, etc.) on the degree to which the vine has developed and the condition of the vine and on the general course of the weather and the amount of progress the mildew has already made.

#### Example of How the Table Is Used

If the infection sets in on 28 May (following rain, dew or fog) starting the infection, and if the average daily temperature from 28 May on has been  $17.2^{\circ}\text{C}$ ., one should look for the length of time of incubation on the horizontal line to the right of the third ten-day period in May and one then chooses the corresponding column immediately under  $18^{\circ}$  average temperature. The point at which the two cross shows that the incubation period is equal to 8-10 days and therefore the pale yellow spots (oil spots) should make their appearance between 5 June and 7 June, but since the period of incubation extends into the first ten-day period in June, one must take pains to also take into consideration the data given in the underlying position for the first ten days in June. The period of incubation will then be 7-9 days and the pale yellow spots could appear between 4 and 6 June. They could appear on 4 June if the relative humidity is high and on the fifth or sixth if the humidity should go down to a lower level, while they may appear at an even later date if dry winds persist. In those years when downy mildew attacks the heaviest and when the grapevines are most susceptible to attack, one must tend, as a precautionary measure, to select the shorter incubation periods.

These first observations, which represent the ABC of the struggle against downy mildew, pointed the way to the advisability of having the winegrowers consult their thermometers and hygrometers every day from the time the grapevine starts to sprout, so they could determine what time would be best to first spray the grapevines. This would avoid useless spray applications, but above all it would make it possible to act at the all-important moment when the mildew would be most sensitive to the toxic action of the copper salt, or other chemical spray.

#### How the Warning Service Decides the Date Infection Has Taken Place

The downy mildew warning service was set up and put in operation very slowly and cautiously in the Aocui district to prevent the possibility of failures which could obviously have created distrust among the winegrowers, thereby forcing the agricultural extension service people to give up the plan which they had in mind to organize a great majority of the winegrowers to carry on a unified campaign against one of the greatest enemies of the grapevine and to do so economically, with less expenditure of materials and



effort. One should bear in mind the fact that all of these winegrowers were small landholders, each owning for the most part no more than three or four hectares of vineyards.

The warning service started as a first, small meteorological station to keep a record of the weather and to study the behavior of the mildew and the first practical tests were carried out. With the passage of time the work progressed from the first few threads of evidence obtained from a few test results until coverage was extended to all the vineyards of those winegrowers who were operating the first weather reporting stations. These were the most advanced winegrowers, that is, the most experienced and most open to the application of new ideas to the art of winegrowing. The next step was to gradually spread the news to the neighboring winegrowers and to tell them when would be the best time to do their spraying. Thus a number of what may be called trial cases were set up for the purpose of demonstration. They were scattered among the midst of the winegrowers in those localities which would attract the most attention and which would give the best example to the rest, while, at the same time the members of the agricultural extension service carried on an intensive campaign of information and education among the winegrowers, to drill the new ideas about the behavior of the mildew and the best way to fight it. At the present time this service is known as the Provincial Inspection Service, a branch of the Ministry of Agriculture and Forests.

At first the most advanced wine growers, who listened to the agricultural experts and who attended the meetings of the agricultural extension service, checked the maximum minimum readings on the thermometers supplied them for the purpose and they also consulted the hygrometers made available at each weather station. Then, at the right moment, after these figures had been recorded on forms given them for the purpose and after studying and comparing them, and having consulted the experts of the agricultural extension service to hear their opinions, the winegrowers doing this work then passed on the word to the neighboring winegrowers to let them know what day to spray to fight the downy mildew. So from then on, by achieving one success after another and by convincing the vast majority of the winegrowers, the transition was made to setting up the present-day system for warning of impending attack by downy mildew, using the well-known characteristic signal rung out by the church bells.

In addition to the above weather data taken by the weather station "lookouts," other information was obtained with the aid of several farmers who also worked on the farms, checking at dawn every morning to see if any of the persistent fogs or heavy dews which occur in the areas attacked by downy mildew had wetted the leaves of the grapevine sufficiently to give rise to a new period of incubation of the parasite. There is no doubt about the fact that this is one of the most ticklish features of the organizational setup of the service since fog or heavy dew can sometimes occur without being recorded by the weather station's instruments and can result in disastrous consequences to the vineyards.

All this has been achieved, but in the wake of overcoming no small difficulties, using a well-designed network of observation points, distributed in different locations to obtain the most significant data. Whenever conditions were ripe for the life cycle of the mildew to start up again, word is sent out in coordination with the central field station to the local winegrowers to "pack up their old kit bags" and get out there and spray, while the prearranged signal is rung out by the church bells throughout the valleys, usually in the morning and always at the same hour.

It is really an admirable sight to see, particularly for one who has seen similar attempts made with more or less limited success in other provinces, as the latter have never been as effective and have never extended to as broad a total acreage as is covered in the countryside around Acqui. It is all the more worthy of admiration when one comes to know just how skeptical certain winegrowers are about any new idea which may be suggested by an agricultural expert and when one sees with what disciplined obedience the winegrowers in and about Acqui carry on their work and how convinced they are of the service's usefulness. In fact, they are even proud to show how much they know and what they are able to do and they know they can help those who still do not understand the importance of the ideas on which the service is based. A state of mind has been created in the Acqui district such that the farmers have particular confidence in the system which is used so that one can even say that nobody can any longer voluntarily refuse to obey the call and openly oppose it, while the great majority of the farmers wait calmly for the sound of the bell to immediately carry out the treatment for protection against the downy mildew. This system depends on the confidence which the

farmers have in those who are responsible for administering the program and the agricultural expert who takes on such a big responsibility should not be afraid to make sacrifices and must also get up early in the morning, at least during the critical periods, to check whether the vines have been exposed to dew, rain or fog, which the downy mildew needs to start its period of incubation.

When the downy mildew threatens and the winegrowers see the agricultural expert engaged in the service out in the country, they leave their fields and, as if called up for roll call, they almost invariably approach him with a bouquet of grapevines in their hands and ask him to take a look at them and give his opinion about any disease which may be present.

Since the time it was started, the administration of the service has changed hands four times and it has continued to progress satisfactorily, in spite of a certain sense of reserve on the part of the farmers towards any new agricultural expert still unknown to them, reminding one of the feelings induced in the minds of the people when approached by the pastor of their parish or by a physician engaged in the performance of his duties. One must conclude with satisfaction that the downy mildew public warning system cannot fail as long as it is run by able men, since it has given clear evidence of the success of its activities and it certainly serves a specific economic purpose which in certain areas is of incalculable importance to the economy as a whole.

Considering, now, the fact that the present-day economic miracle seems to be affecting business and enterprise of all kinds, particularly in trade and industry, and is bringing about a shortage of farm workers, there is a definite need to put in operation every possible device which will bring about a saving in the human labor which is expended in the fields. Consideration should also be given the possibility of entrusting the application of chemicals for combatting downy mildew to aircraft, particularly helicopters and experiments of this kind are now underway with a view to the probable long-range requirements of agriculture in the future. In any case there will still be a need to apply the chemicals at the right time and this can only be done when the temperature and moisture conditions are ripe for development of the downy mildew. One should also, lastly, consider the fact that the shorter length of time which the relatively new fungicides remain

effective requires that strict attention be given to the exact time schedule of the parasite's incubation period. The new materials which are already being extensively used require much greater care in this respect than the older Bordeaux mixture.

#### Operation of the Public Downy-Mildew Warning Service

In substance, the operation of the downy mildew warning service is administered by an agricultural expert of the Ispettorato Agrario (Agricultural Inspection Service). The setup consists of a more or less densely scattered network of lookout stations (small weather stations) situated in the best positions to record the different microclimates of the affected area. All of these substations report to a central coordinating station. The agricultural expert in the central station examines the accumulated weather reports and keeps a record of them. He sifts out the various reports which he receives and which come to him through different channels, from both lookouts and other dependable sources of information. He investigates any contradictions which become evident from among the different data which he receives and he compares this data with the findings which he makes in person in the vineyards. He determines the date on which the period of incubation started and from this point on he follows the course of the weather and decides on every step which is to be taken, basing on the time of the year during which the mildew develops and calculates the probability which any period of incubation which has set in has of achieving a successful development.

Performing in all respects the function of an actual nerve-center for the entire setup, the center is satisfactorily equipped to follow up the stages of development of the parasite through each of its phases and also from a scientific standpoint. He is equipped with a thermograph or recording thermometer, a hygrograph or recording hygrometer, a picnometer, geothermometers, which probe the temperature of the soil to check development of the oospores, and a microscope for analysis of the various fungus growths that attack grapevines, so he has available to him all the laboratory instruments needed to overcome or to contain within limits any surprises the parasite may possibly have in store.

As each new period of the parasite's incubation falls due, the head of the warning service sends out the call for spraying the vineyards, calling the parish priest by telephone so the call will be rung out in the valleys by the

church bells on the regularly agreed hour of the day which has been chosen. In accordance with observations carried out over a period of a third of a century of experimentation and which have been issued as standards by the Piedmont Observatory of Plant Pathology, the general standards applicable to regulate the spraying may be summed up as follows:

#### Spraying Methods for Downy Mildew

The way downy mildew has behaved in the past would tend to indicate that the time for first spraying the vine depends most of all on the course of the weather during the period between the preceding fall and the start of spring in the current year.

It should first of all be pointed out in this respect that the intensity of the first conidia infection depends on the "charge" of oöspores existing in the ground, which depends, in turn, on the severity of the attacks that took place during the preceding fall; it also depends on the amount of rainfall that has prepared the way for the first wave of attack as well as the extent to which the vines have already developed at the time the attack takes place.

The first time in the year that downy mildew attacks the vineyards in the Acqui district is in spring, usually in the month of May when all three conditions required are all present at the same time, namely, at least 10 mm. rainfall over the past two or three days, minimum temperatures over +10°C., and buds which have attained a length of 6-10 cm. The first two conditions are absolutely necessary in order that at least part of the oöspores may germinate. The third condition is an indication of the extent to which the openings of the stomata of the first tender leaves have been differentiated, allowing the parasite to get a hold on them.

In practice there is no doubt that the time is already ripe for carrying out the first liquid treatment, preferably using products which do not need to be neutralized by lime, if there has been heavy rainfall between autumn and the beginning of spring, if the minimum temperatures are around 9° to 10° C. while the maximums are around 19° to 20° C. and if the grapevines have started to sprout. In fact, Bordeaux mixture very readily burns the tender leaves and tiny clusters due to its toxicity, particularly on vines of white grape varieties. If, however, at the same time the leaves are still quite undeveloped and the shoots have

a tomentose appearance, it would be better to give preference to treatment using copper sulfate powder, applying it very early in the morning because the dew helps the powder to adhere to the foliage. If, however, the fall to spring period has been generally dry, the first treatment should be given only after temperatures have remained at all times above 10°C. for at least seven or eight consecutive days and solutions which do not require neutralization with lime should be used to prevent damaging the still tender growth. It becomes absolutely necessary in all treatments which follow the first to adhere methodically to the parasite's incubation time schedule to avoid resorting to hit-or-miss methods. For all practical purposes the period of incubation is understood to represent the period of time between the promycelium's penetration into the stomata and the moment when the pale yellow spots or oil spots, or better yet, the moment when the white mold first appears on the leaves. This stage in the development of the parasite depends essentially on the ambient temperature (most favorable 21°-24°C.) and the rainfall or dew which wets the susceptible organs of the plant for several hours (1½ to 2½ hours). The film of water is used by the zoospores to swim and reach the stomata where the promycelium undertakes a renewed attack on the vine.

The time schedule enables one to see, in effect, just when the effects which are brought about by the conidia will first make their appearance, which is the most effective moment in which to act to apply chemicals to prevent the disease.

The proper time and date selected for application of the chemicals to the vine depend on the temperature and humidity and temperature readings taken by the weather reporting stations, starting specifically with the period of rainfall or contaminating dew and taking into account the duration of the period of incubation and, more specifically, the time when such a period would draw to a close. A certain period of time may intervene, though, between the first appearance of the "oily spots" and the downy white fungus growth. If the countryside shows no obvious signs of attack by the mildew one can wait until the oily spots appear on the leaves before spraying, or, if the air is dry, one can even wait until the white mold makes its appearance. In doing so the game becomes hazardous and one will have to act as promptly as possible, hoping that no new period of incubation will be started by any unexpected rains which may fall while the vines are exposed without any protection.

Two different possibilities can, in effect, be taken into consideration in applying the second course of treatment:

First case: The wetting precipitation (the rain, persistent fog or dripping dew) occurs either immediately after or even a few days after the first treatment. Treatment will be started on the day the period of incubation provided for in the time schedule has terminated. If, however, the weather continues dry, the oil spots may appear and where they do not appear or wherever the foliage of the vines has already developed to a considerable extent the treatment should be applied just the same as a precautionary measure.

Second case: The wetting precipitation occurs considerable time after the last treatment has been applied (8-10 or more days). When the period of incubation has expired, the second application should be made regardless of whether or not the characteristic oil spots have appeared on the leaves, in order to protect the new foliage.

After the first two applications mentioned above, which absolutely must be carried out, even if only as a precautionary measure, the winegrowers will be able to face the subsequent difficulties in the struggle against downy mildew with confidence by watching closely for any signs of rain or wetting precipitation such as may be provided by persistent fogs or by dripping dew. The third and subsequent sprayings can then be carried out when the period of incubation indicated by the time schedule has elapsed, checking for any appearances of "oil spots" which may occur, even if only in isolated instances, and watching for development of white fungus.

To do so the vines will have to be inspected daily, going down the rows and in doubtful cases checking the leaves for their transparency, especially those carried by the buds springing from the trunk, which, being nearer the ground, receive a greater amount of dew.

Once the oil spots have appeared and the treatments have been immediately carried out, it may rain or wetting precipitation may occur. The oil spots will immediately become fertile, becoming rapidly covered with the white mold carrying the conidia of the parasitic fungus, which, under these circumstances will be able to germinate rapidly. In such a case, though, they would find the vine effectively protected by the most recent spraying carried out which

left a film of fresh fungicide on the foliage just at the most effective moment to take its fullest effect. There will be no need, then, for the time being, to repeat the spraying.

If the treatment is applied after the oil spots appear and the weather remains moist but without any wetting precipitation taking place, the white mold will appear, but the conidia cannot germinate until rain, fog or dew have been precipitated.

It will still be wise to carry out the treatment even in the absence of conditions giving rise to the mold, adding fresh fungicide after several days have passed to ensure that fresh fungicide will always be present at the most critical moment.

If the weather should remain dry after appearance of the oil spots and application of treatment, without even slight traces of precipitation, the oil spots will remain sterile and there would be no reason to resume treatment.

If the season passes without even any dew and without any low-hanging fog at all, then one can safely consider the treatments ended because under the withering heat of summer during July and August any attack made by the fungus is doomed to failure.

One should in any case keep in mind the advisability of always carrying out a supplementary course of treatment at the end of the downy mildew campaign (end of August-beginning of September) in consideration of the usual rainfall which occurs at that time. These sprayings are used to limit development of the downy mildew on the lower laterals, to improve maturation of the product and to cut down the number of oospores to the advantage of next year's campaign.

This activity aimed at organizing and standardizing the efforts directed towards protecting grapevines from attack by downy mildew was presented as the result of teamwork because that is the type of protective system which has been in effect and put in practice in the Acqui district for a long time. This does not mean that similar steps cannot be undertaken and undoubtedly even with greater success by individual winegrowers. It is necessary, though, if the struggle is to be carried on effectively that such men be well prepared from a technical standpoint, that is, that



they should have a basic knowledge of the problem presented by the parasite and of its life history. Neither should they allow themselves to be diverted in their efforts by taking the matter too lightly, which could lead to disastrous consequences. A few years ago, in July and even in August, when the winegrowers have the habit of putting away their sprayers, convinced as they are of having overcome all the dangers of the campaign against downy mildew, the sound of the warning bell echoing through the valleys due to a siege of unusual weather fell discordantly on the ears of no small number of the winegrowers, including even certain weather lookouts. But after a short time it was found that here, too, the method used in the struggle had not failed this time either and many disbelievers were promptly persuaded of the error of their ways in not having applied the needed treatment. Surprises can always happen and it can well be said that every campaign against the downy mildew has a tendency to take on special features of its own.

It seems that certain authors do not agree on the wisdom of using a collective system covering a broad area where the climate can vary considerably from one zone to another. This idea certainly has its merits, but, on the other hand, it has been found in the greatest number of cases that the difficulties involved become greater whenever one attempts to depend on a system of voluntary individual action without any source of information or means of comparison other than the simple time schedule of treatments outlined in a more or less sketchy manner and adapted to changes in the weather.

It is admitted that it is impossible to attribute any absolute, mathematical value of certainty to the incubation time table for downy mildew of the grape, since there are too many factors involved, some of which cannot be calculated in advance and hence escape ordinary observation, but which have their effect on the biological development of the parasite.

The organized warning service team wishes, in fact, only to provide a simple warning to those who do not understand and do not know the hidden "secrets" of the battle against the parasite. This warning is intended simply to call the winegrower's attention to the steps which he himself should take during the most critical period when the vineyards appear to be in greatest danger. If then, using his own knowledge, he can tie in the overall observations made by the group with his own more accurate and detailed

observations of moisture and temperature values, he will be that much better off and the campaign against the downy mildew will benefit just that much more.

In order, though, that the struggle carried on on an individual basis may be more effective, though, the individual winegrowers would have to at least develop a point of view which would match that of the lookout in his training, his enthusiasm for his job and the confidence he has in his ability to do the job.

### Evaluations of An Economic Nature

Ever since 1930, when the downy mildew warning service started in the Acqui district, up to 1955, representing the culmination of a quarter of a century of activity, the average number of yearly sprayings advised for the vineyards taking part in the joint effort was 6.4 (an arithmetic average) against 12.6 spraying normally carried out by winegrowers who, standing on the sidelines and failing to participate in the team effort, failed to respond to the warnings.

Over the past ten years of activity, from 1953 to 1962, these arithmetic averages have remained about in the same ratio, being 6.5 sprayings in the areas accepting the service and 11.2 in the areas outside the zone covered by the service.

<u>Year</u>	<u>Number of sprayings indicated by the downy mildew warning service</u>	<u>Number of sprayings applied in the bordering area not subject to the warning service</u>
1953	8	15-16
1954	9	17-18
1955	4	8-9
1956	5	8-9
1957	11	15-16
1958	4	7-8
1959	9	13-14
1960	8	11-12
1961	4	7-8
1962	3	6-7

To fully appreciate the economic results which can be achieved by strictly following the indications given by the downy mildew warning service, one should consider the

fact that nowadays for each treatment one needs on an average at least 10 liters of an approximately 1% fungicide solution of copper sulfate or of the equivalent chemical product needed, together with the ordinary back-pack sprayers of either the fixed or wheel-mounted type (the latter being more frequently used in the Monferrato zone), but operated by hand, to spray one hectare of vineyards (growth with a supporting trellice, a simple, Guyot system of pruning and with rows spaced at equal distances, from two to three meters apart) requiring an average of 20 to 30 hours of work under normal conditions.

It will be well to note in this respect that the downy mildew warning service does not aim simply at reducing the amount of fungicide used. The most important goal of the service is that of letting the winegrower know in time the best time to apply the fungicide chemicals to protect the greater part of the product. It can be said that this goal has been largely achieved and this is shown by the fact that none of the winegrowers has ever left the fold, while, instead, the system whereby the applications of spraying are disciplined and subject to control has continually increased in favor so that memberships in the service from the areas covered by the weather stations reached 100% in a short time.

It should also be remembered that in addition to reducing the cost of protecting the vineyards by decreasing the number of treatments which are necessary, which is advisable in the majority of cases, and increasing the production of grapes by more timely and effective action in protecting them from the parasite, there is also a social factor which now deserves careful consideration, namely, the shortage of labor in agriculture, which continually becomes worse and which therefore requires that systems of cultivation be adopted which will decrease the expenditure of human labor as much as possible.

#### General Concluding Remarks

We have here a public service which calls for but a modest expenditure for apparatus and which is very economically operated compared with the enormous savings which can be garnered. The desire to strengthen and improve the system and to keep the weather lookouts' equipment up to date led to the idea that a number of problems and even complicated ones could be solved by some form of association requiring an almost negligible expenditure, either by way of public administration or through the winegrowers' own trade organizations. Thus in 1956 at the initiative of the agricultural

inspection service an Associazione dei Comuni dell'Acquese (Acqui District Association of Municipalities) was founded covering a district which took in 32 townships. This was done to ensure improvement and continuity in the operations of the downy mildew warning service. Although the Agricultural Inspection Service continued to operate the service and accept responsibility for it, the District Association of Municipalities agreed to take care of maintaining the equipment of the weather lookout stations and to pay for installing telephone connections between the various lookout posts and the Agricultural Inspection Service and between the latter and the parish church (which from the very start accepted with enthusiasm the request for cooperation in performance of this public service, consenting to use of the church bells), for transportation to gain access to the vineyards, for collection of suspect sample material to be studied under the microscope when necessary and, lastly, to give the lookouts adequate compensation for their cooperation, which is of decisive importance.

Thousands of small winegrowers with small land holdings are united, with a sense of common solidarity with the agricultural experts and they obediently follow the advice of the warning service as they have been completely convinced by the successful outcome of an undertaking which has thirty years of activity.

It would be impossible to bring to a conclusion this brief paper dealing with the operation of a service which is undoubtedly the only one of its kind in Italy in respect to the amount of territory covered, the excellent condition of the equipment in operation, the state of organization of the taking of readings and communications among the lookout stations and the spirit and sense of dedication with which agricultural experts and winegrowers work, without expressing the opinion that this type of lookout service should be extended to a wider circle of important crops and that the farmers should be persuaded of the great importance of knowing and wisely applying accurate regulations of a similar kind to the performance of their work.

The problem of protecting the crops is not simply a question of the grapevine alone. It needs to have attention focused on it to make all such efforts successful and fruitful so the agricultural sector of the economy will be able to achieve satisfactory economic results. Neither is it out of line to express the idea that it would be

owned and operated by the farmers themselves, guided and supported by their own agricultural experts, since it would be unthinkable with the logical expansion and multiplication of similar undertakings that the responsibility and expense of a plant pathology service thus conceived should fall on the shoulders of institutions whose activities extend to sectors which cover ever wider unlimited areas of activity.

### SUMMARY

This report gives an interesting example of the application and practical economic use of meteorological data on temperature and humidity and their effect on the life cycle of downy mildew.

The incubation time table for this fungus, worked out by Küller on the basis of early observations, was adapted to the Acqui district and improved in that the length of period of incubation was related to average daily temperatures between the start and finish of the incubation period.

Data obtained from the instruments and the results of investigations carried out on a scientific level were compared with practical findings obtained by direct observation of the vines, special attention being given the appearance of any fog or dripping dew such as could start a period of incubation. —

Even in following all these indications one still cannot always guarantee perfect results, but in spite of this fact, the information thus gained proved sufficient and had significant practical and economic value to the winegrowers of the Acqui district.

Three decades of work in which the efforts at combatting the downy mildew were conducted on the basis of the mildew's own incubation time schedule have led to savings of about 50% in time and materials used in spraying taken as a general average.

The example given, if not the only one of its kind, is at least unusual when one considers the size of the area taken in, the advanced stage of training of the men and the instruments at their command and the degree of organization and sense of solidarity which exists among the winegrowers.

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In order that such attempts may prove successful when carried on collectively over such a wide range of territory, there must be within the area at least a certain minimum degree of uniformity in the conditions of the environment and, in particular, of the climatic conditions. There must also be a certain period of time which falls between the various incubation cycles of the parasitic fungus which occur over a period of time.

Dr. Alberto Messori  
Inspector General of the Italian  
Ministry of Agriculture and Forests,  
Head of the Turin Province  
Agricultural Inspection Service

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Table (for use of Locks) to Determine the Length of Incubation Periods

The time, given in number of days, is determined on the basis of the ten-day period and the average temperatures recorded by the downy mildew weather stations.

Ten-day period in which downy mildew infection starts & develops in period of incubation	Average Temperature in Degrees Centigrade, in Period When Downy Mildew Infection Starts and During Its Period of Incubation									
	13°	14°	15°	16°	17°	18°	19°	20°	21°	22° 23° 24°
April, 3rd 10-da. period	14-16	13-15	12-14	11-14	11-13	10-13	10-12			
May, 1st 10-da. period	14-16	13-15	12-14	11-14	11-13	10-13	10-12	9-12		
2nd " "	14-15	12-14	11-13	10-13	10-12	9-12	9-11	8-11	8-10	8-9
3rd " "		12-13	10-12	9-11	8-10	8-10	8-9	7-9	7-8	7-8
June, 1st " "		10-11	9-10		8-9	7-9	7-9	7-8	6-8	6-8
2nd " "			9-10		8-9	7-8	6-8	6-7	6-7	6-7
3rd " "					8-9	7-8	6-7	5-7	5-6	5-6
July, 1st " "						7-8	6-7	5-6	4-6	4-6
2nd " "						7-8	6-7	5-6	4-5	4-5
3rd " "							6-7	5-6	4-5	4-5
August							6-7	5-6	4-6	4-5 4-5

Figures above show the duration of periods of incubation in number of days during the different ten-day periods and for the different average temperatures recorded.